LOGGING DECK ORGANIZATION WITH A BUNDLER

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ABSTRACT

The original John Deere 1490D Slash Bundler is mounted on a forwarder so that it can collect woody biomass scattered throughout a tract. However, typical logging operations in the southeastern United States delimb and top at the landing, so logging residues are concentrated at the landing. In a current study by researchers at Auburn University and the Southern Research Station, the bundler unit was mounted on a motorized trailer for stationary use on a log landing.

Worksite management analysis is needed to investigate equipment placement and work coordination needed when adding the trailer-mounted John Deere B-380 Slash Bundler to a log landing. In field trials to be installed during the fall of 2009, researchers will analyze the working area needed for the machine, determine optimal equipment placement, and identify coordination with existing landing functions. This paper documents some of the planning considerations for integrating bundling logging residues into a conventional harvesting operation.

Keywords: *logging residues, biomass, bundle, harvesting, equipment*

INTRODUCTION

The most cost-effective approach to biomass removal appears to be integrated recovery with traditional harvesting operations. In a study installed in Alabama in 1983, Stokes et al (1985) and Watson et al (1986) examined two methods of integrating biomass harvesting into a conventional roundwood harvest. The study examined harvesting biomass in a single pass or in a two-pass operation. The single pass operation involved felling and skidding the standing energywood at the same time as the other products. The feller-buncher piled the energywood separately from the roundwood for the skidder. On the landing, roundwood was sorted and loaded tree length and the energywood was chipped. Alternatively, the two-pass method felled, skidded and processed the energywood in the first pass, and a second operation was used to remove the merchantable roundwood. The one-pass method resulted in a better recovery of biomass compared to the two-pass operation because the limbs and tops from the merchantable roundwood were included in the biomass volume totals. Additionally, the higher volume of biomass removal of the one-pass operation resulted in a lower cost per ton compared to the two-pass operation.

When logging residue removals are integrated into roundwood harvesting operations, the volume removed can vary based on what material constitutes the residues. Residues may include volume from limbs, tops, and cull material; and can sometimes include standing non-merchantable woody biomass of all species that measure between one and four inches DBH that can be harvested by the feller-buncher and skidder. In Georgia, Westbrook et al (2007) compared biomass harvesting volumes between operations where one treatment included limbs and tops only, and another treatment that included limbs, tops and non-merchantable volume. In the Georgia study, the biomass volume produced was not significantly different (at the 5% level) between the two treatments. The challenge is often to process the residues so they can be handled cost-effectively.

Roadside biomass processing is generally accomplished by chippers as in the previously mentioned studies installed in Alabama and Georgia. The cost of biomass harvesting can be lowered, and recovered volumes increased when biomass removals are integrated with conventional forest product harvesting. While traditionally this is done by adding a chipper or grinder, an alternative approach is biomass baling or bundling. A new prototype roadside bundler has been developed and this paper examines the integration of this type of biomass processing into conventional forest product harvesting operations. Bundles offer densification for transporting biomass, but bundles can be stored and handled with grapple-equipped machines while preserving the ability to further comminute the material to meet specifications of a variety of biomass facilities.

THE TRAILER-MOUNTED JOHN DEERE B-380 BUNDLER PROTOTYPE

The John Deere 1490D Slash Bundler is a commercially available machine that collects and compresses logging residues into dense “bundles.” It is commonly used in operations that employ cut-to-length (CTL) harvesting systems, especially in Nordic countries. In CTL systems, trees are felled and processed at the stump leaving residues scattered throughout the stand. Sometimes, the harvester is able to create small piles of logging residues, but these are also scattered through the stand. The John Deere 1490D Slash Bundler is mounted on a forwarder, enabling the machine to maneuver through a stand to collect and bundle scattered residues into a composite log (Figure 1). In a cut-to-length operation, completed bundles are transported to roadside by a forwarder.

Fig 1. The John Deere 1490D Slash Bundler (*photo: R. Rummer***)**

A typical logging operation in the southern US employs a tree length harvesting system. In this system, trees are felled and skidded to a landing where they are then delimbed and merchandised. Since the logging debris is concentrated at or near the landing, this type of operation does not require a bundling machine to be mobile within the stand. The John Deere 1490D Slash Bundler has been modified by researchers at Auburn University to take advantage of concentrated logging residues on typical southern logging operations. Since mobility is not needed in this application, the B-380 Bundler has been removed from the forwarder and mounted on a trailer (Figure 2). Cutting Systems Inc. provided a motorized trailer to serve as the power unit for the bundler. This heavy weight trailer was originally designed to support a delimber, so it is applicable in the forest environment. The trailer's design makes it easy to move the unit on the landing with a skidder or log loader grapple. One area that is not yet known is how to effectively add the bundling functions to a logging operation.

WORK DESIGN

Nadler (1963) defines work design as "…the systematic investigation of contemplated and present work systems to formulate, through the ideal system concept, the easiest and most effective systems and methods for achieving necessary functions." The work system for incorporating the trailer-mounted bundler to a landing operation includes the complex physical, mechanical and human activities necessary to process forest products in an efficient and cost-effective way to maximize production (loads).

Fig 2. The trailer-mounted John Deere prototype bundler

For this project, the ideal system is one that includes biomass bundling, using prototype equipment, in an integrated harvesting operation that does not negatively impact the production of other forest products. Incorporating the trailer-mounted slash bundler into a traditional southern logging operation requires some planning about how to add this new equipment and associated bundling activity to an active, and often congested, log landing. Planning may begin with identification of existing equipment and observations of the current landing activities, or system. Common landing equipment includes at least one log loader, a delimber and a cut-off saw (the delimber and cut-off saw may be incorporated into one piece of equipment). Landing activities (known as necessary functions) often include delimbing and processing stems, sorting products, log storage, and truck loading. Other landing activities often include ingress and egress for the skidder, drop locations for the skidded stems, a truck turnaround, and a load trimming area. The addition of the trailer-mounted bundler requires careful consideration for incorporation so that it does not negatively impact other existing functions.

The adoption of the trailer-mounted slash bundler into a traditional logging operation requires an understanding of how the bundler works and where to add the new piece of equipment to an active logging deck. Typical mechanical operations for the bundler include the elements of feeding logging residues, compressing the material, feeding the compressed material forward, wrapping the bundle with twine, and cutting the bundle to a specified length. For the prototype unit, an independent knuckleboom loader is needed to feed residues into the bundler and to arrange (or pile) the completed bundles. Other expected elements for proper functioning of the bundler operation would include loading bundles onto trucks, logging residue arrangement, and regular maintenance. All of these functions must be arranged within the operating reach of the loader. For example, the conceptual drawing in Figure 3 assumes that a loader has a 25-ft reach. The area within operating circle contains the equipment and material storage areas needed for bundling logging residues. Based on this figure, it is difficult to see an arrangement with a single loader that would include processing and piling for traditional roundwood products. Thus, the drawing in Figure 3 supports using a separate loader for the bundling activities.

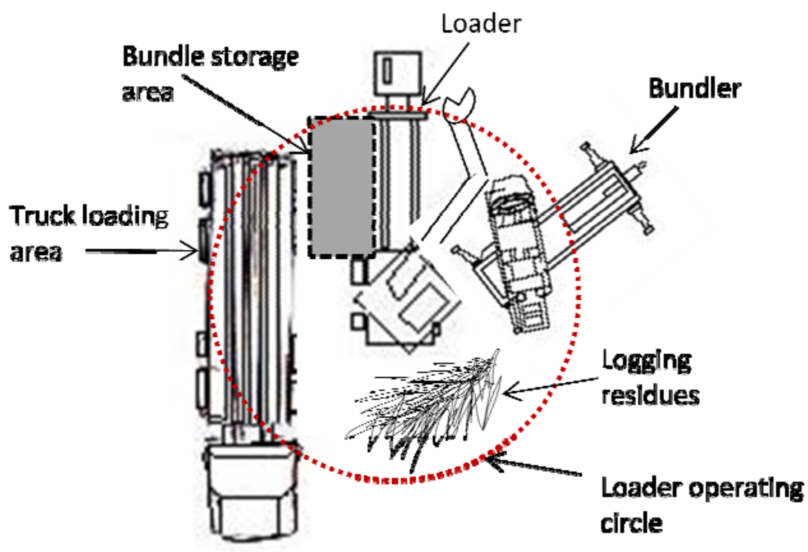

Fig 3. Conceptual drawing of equipment arrangement on a landing with a single loader assigned to bundling functions.

The number of loaders required on the landing is an important topic to consider when implementing an integrated bundling activity on a conventional harvesting operation. Loader production can be impacted by many functions including the number of skidders bringing stems to the landing, the volume to be removed from the stand, skidding distance, truck availability, and a variety of other factors that can change from landing to landing. When biomass bundling is added, additional loader functions are added to the workload. Analysis is needed to determine whether the bundling functions can be integrated with the operations of the existing loader, or if another loader should be added to the equipment mix. If another loader is added, the work system should analyze how logging residues are moved from the roundwood processing area to a separate bundling area, or whether the additional loader should be located within reach of the stem processing residue area. Safety concerns should address the distance between the roundwood processing area and the bundling area. If activities are separated on the landing, or if additional storage space is needed for bundles, the size of the landing area may increase.

A variety of alternatives can be explored to gather information for feasible solutions to incorporating bundling on conventional southern logging operations. Researchers at Auburn University will develop different scenarios for incorporating the prototype bundler, and then review and field test the alternatives on active logging operations for feedback on the process and production of the equipment.

An optimal solution for equipment placement would allow for worker safety and efficient processing and loading of all products. The Washington State Department of Labor and Industries (2009) has safety standards for logging operations that include the requirement of an unimpaired horizontal clearance of at least three feet between the rotating superstructure of any logging machines working on a landing and any adjacent object or surface. Adding a new new machine and activity to a congested landing area may create new hazards, bottlenecks and impact the coordination between equipment operators. When bottlenecks occur, cause-effect relationships can be identified for production inefficiencies, and corrective actions can be determined and implemented.

PRODUCTION AND COST CONSIDERATIONS

Costs for integrated biomass recovery can be impacted by the availability of logging residue volume. Westbrook et al (2007) indicate a trend of increasing delivered costs as the ratio of the number of truckloads of roundwood required to produce a vanload of chips increases. When processing limbs and tops for biomass, their study found that it took 12 loads of roundwood to create 1 load of biomass chips (average load = 26 tons). A bundle weighs approximately 100 pounds/ft of length. If bundles are cut in 10 ft. lengths, each bundle would weigh approximately 1,000 pounds. So, if the bundler field trials included similar stands as those from the Westbrook et al (2007) study, 52 bundles would be created for every 12 loads of roundwood.

In an analysis of the original John Deere 1490D Slash Bundler, Patterson et al (2008) reported production rates from their time and motion study that ranged from 23 to 36 bundles/hr, or an average of 30 bundles/hour. In this non-integrated application, the original mobile bundler processed logging residues that were in piles on the landing. These production rates may not be applicable to the integrated application because delays may occur when logging residues aren't available until the loader completes processing individual stems. When using an average production rate of 30 bundles/hour, the trailer-mounted bundler could potentially produce 52 bundles in less than two hours. This production rate suggests that the bundler would only be utilized for about 25% of the scheduled hours, based on an 8 hour day, if the ratio of biomass to roundwood is 1:12.

The trailer-mounted bundler is a prototype machine, so equipment pricing information is not available. However, a sensitivity analysis was performed to determine the impact of capital investment cost and utilization rates on the cost per green ton produced. A machine rate analysis (Brinker et al 2002) was used for the cost calculations with the following assumptions used for comparison purposes: 5 year life, 10% interest, 20% salvage value, fuel usage of 2.2 gals/hr at $2.00/gal (off-road diesel), 50% repair and maintenance over the life of the machine, 1.5% for insurance, and 30 bundles/productive machine hour. The cost comparison for the bundler, without an operator, is displayed in Figure 4.

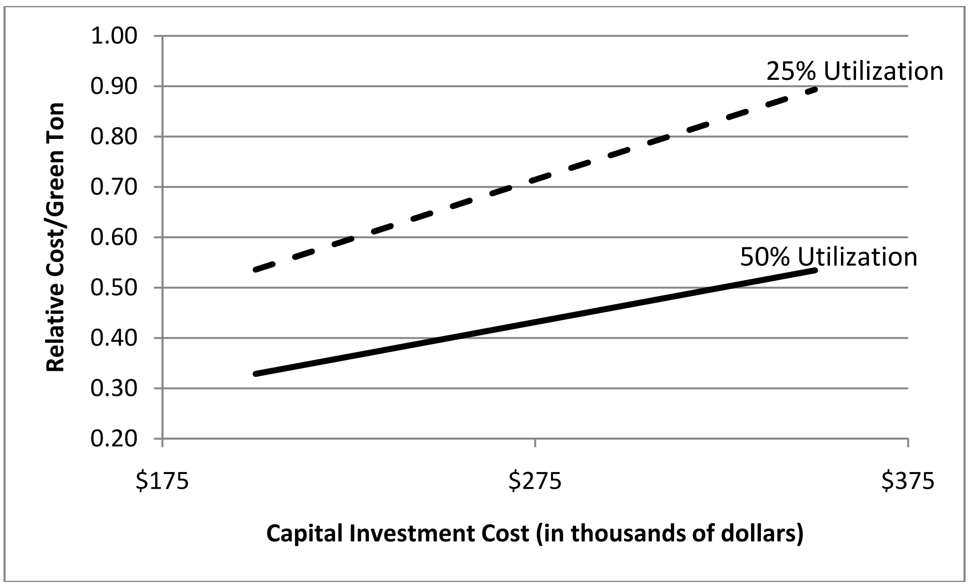

Fig 4. Sensitivity analysis of capital investment cost and utilization rate on the cost of producing bundles

The ratio of biomass to the tons of roundwood produced will affect the utilization of the bundler. As the ratio decreases, more biomass is produced per ton of roundwood. An increased supply of logging residues to the bundler would raise the machine's utilization rate and lower the cost/green ton ($/gt) of each bundle produced. Figure 4 displays the impact that could be realized if the ratio of 1 load of bundles to 12 loads of roundwood (1:12) is increased to 2:12. The $/gt reduces by approximately 40% at the higher end of the capital investment cost scale. The slope of the 50% utilization line in the graph in Figure 4 indicates that the relative cost of producing bundles is not as sensitive to the of capital investment cost as it is to the utilization rate.

Equipment utilization of the bundler could be higher than in an integrated operation where a chipper is used to process biomass. This is due to the chipper waiting time that is often experienced when chip vans aren't available. In a bundling operation, there aren't any delays caused by truck availability because bundles can be stacked and stored on the landing until a truck is available.

SUMMARY

Adding a new piece of equipment to a log landing requires planning prior to implementation. A balanced worksite will have readily available logging residues, coordinated functions, and equipment placement so that production is maximized. Through time and motion studies, or work sampling, production efficiencies can be analyzed for system improvements. The human element can also impact the balance of landing operations, and a variety of systems could be ideal for different logging operations.

The trailer-mounted bundler unit is a prototype, so no pricing is available at this time. However, a sensitivity analysis indicates that costs will be sensitive to the utilization rate and the volume of logging residues available.

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